

PROCEDURE FOR DISTILLATION COLUMN DESIGN

1. Determine the Feed Characteristics, Compositions, Azeotropes, Miscibility, Reactions, Relative Volatility.
2. Determine the Feed Density, Feed Cp, Feed Latent Heat.

$$\text{Feed Density} \left(\frac{x_1}{\rho_1} + \frac{x_2}{\rho_2} \right)^{-1} \quad | \quad \text{Feed Cp} \left(x_1 * Cp_1 + x_2 * Cp_2 \right) \quad | \quad \text{Feed latent Heat} \left(x_1 * \lambda_1 + x_2 * \lambda_2 \right)$$

3. Convert the Given Volumetric Flowrate to Mass flowrate (by dividing with Feed Density) and Find the Components Mass.
4. Calculate Distillate Flowrate based on Desired Output.
5. Determine the X_d , X_b .
6. Draw McCabe Thiele Graph - VLE Curve, Diagonal. Locate the X_d , X_b points on Graph.
7. Point X_F on diagonal and Since $q = 1$, the q -line goes vertical extending through VLE Curve.
8. Draw a line from (X_d, X_d) through Pinch point (point where q -line connects on VLE Curve) and extend it till y -axis.
9. Using Equation 1, find the $R_{\min}$.

$$R_{\min} = \frac{X_d}{y} - 1$$

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10. Calculate Actual Reflux ratio - $2 * R_{\min}$ or $1.5 * R_{\min}$
11. From the Equation 2, find the intercept and connect the intercept to (X_d, X_d) passing through Feed line.

$$\frac{R}{R+1}x + \frac{X_d}{R+1}$$

12. Draw Rectifying Operating line and Stripping Operating line.
13. Construct Stages from (xd, xd) to (xb, xb)
14. Calculate the number of Stages, and Calculate height of the column based on type of Internals.

Tray Type: $\frac{\text{Theoretical Stages}}{\eta} = \text{Actual Stages}$ **Packing Type:**

$(HETP) * \text{No. of Stages}$

15. Calculate the Vapor Flowrate:

$$V = D * (1 + R)$$

16. Determine the Column Diameter

$$\frac{Q_v}{\text{Velocity}} = \text{Column Area}$$

$$\sqrt{\frac{4 * A}{\pi}} = \text{Column Diameter}$$

Utilities Calculations:

1. Steam Consumption:

$$Q_{\text{Reb}} = m_f * C_{p_f} * (\Delta T) + m_v * \lambda_{\text{mix}} \quad (\Delta T = (\text{Temp} \in \text{Kettle} - \text{Temp} \in \text{feed}))$$

$$\text{Steam Consumption} = \frac{Q_{\text{Reb}}}{\lambda_{\text{Steam}}}$$

2. Cooling Water Requirement: $\frac{Q_{Cond}}{Cp_{Water} * 4 \text{ } ^\circ C}$

3. Reboiler Sizing:

$$Q_{Sen} = m_f * Cp_f * (\Delta T) \quad | \quad Q_{latent} = m_v * \lambda_{mix} \quad \rightarrow \quad Q_{Reb} = Q_{Sen} + Q_{latent}$$

$$\frac{Q_{Reb}}{U * LMTD} = \text{HT Area} \quad \rightarrow \quad \frac{Total HT Area}{SA of One tube} = \text{No. of tubes}$$

4. Condenser Sizing:

$$\frac{Q_{Cond}}{U * LMTD} = \text{HT Area} \quad \rightarrow \quad \frac{Total HT Area}{SA of One tube} = \text{No. of tubes}$$